ARRL Ex Parte Presentation[1]
to the Office of Engineering and Technology
Federal Communications Commission
April 23, 2002

ET Docket No. 01-278

Summary:

In previous Ex Parte presentations in this proceeding, ARRL has provided technical analyses of the field strength and impact on the Amateur Radio Service of the RFID systems proposed in the NPRM. ARRL concluded that the frequencies, signal levels and duty cycles proposed in the rules would cause harmful interference to Amateur Radio stations. ARRL has since then completed field tests of the effects of signals that simulate SAVI device operating parameters on Amateur Stations. The field tests validate ARRL's conclusion.

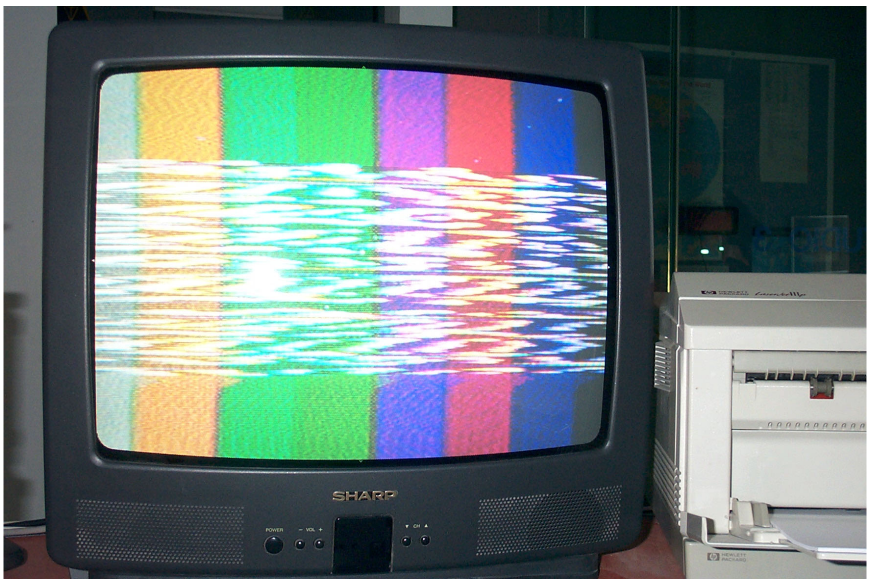

Figure 1. Under the proposed rules, Amateurs that experience interference from a single RFID device could see this level of interference continuing for 120-second periods, with 10-second breaks between transmissions.

SAVI Technologies argued that their RFID devices would not result in harmful interference. Although SAVI offered “field tests” in order to demonstrate that the proposed rules would not result in harmful interference, their tests and presentations did not provide sufficient information about test conditions and methods to enable a quantitative analysis of their methods or results. The result summaries SAVI provided the Commission asserted, in effect, that a SAVI Tag device did not break the squelch of an FM receiver; therefore the proposed rules changes will have no effect on

[1] This is a written Ex Parte presentation, prepared by ARRL Laboratory Supervisor Ed Hare, Lab Engineer Mike Tracy and Senior Engineer Zack Lau.

amateur communications. SAVI also performed a test involving an EME receiver. In this test, the *on-channel* received signal level was reported as “S9” (typically –123 dBW at VHF). RFID signals of this level between 425 and 435 MHz are more than strong enough to cause harmful interference if allowed in the Amateur band.

The RFID signal level used in ARRL's tests was the same as that proposed in the Notice in this proceeding. It used a modulation type and bandwidth typical of RFID devices. This station was operated at the ARRL Administrative Headquarters building, using the outdoor antennas on the rooftop. The simulated RFID signal was received at typical amateur 70 cm SSB and amateur television stations located approximately 90 meters away from the radiating source. The receive antenna was a circularly polarized Yagi array with 14.6 dBic of gain (equivalent to 11.6 dBi linear).

A received simulated RFID signal level of –106 dBW to the amateur station receiver input was measured using calibrated test equipment. This received signal level is clearly high enough that it would preclude normal Amateur operation on frequencies within the passband of RFID signals operated under the proposed rules. Many Amateur stations utilize receivers that are more sensitive than those used in the ARRL test.

Simulated RFID Test Signal:

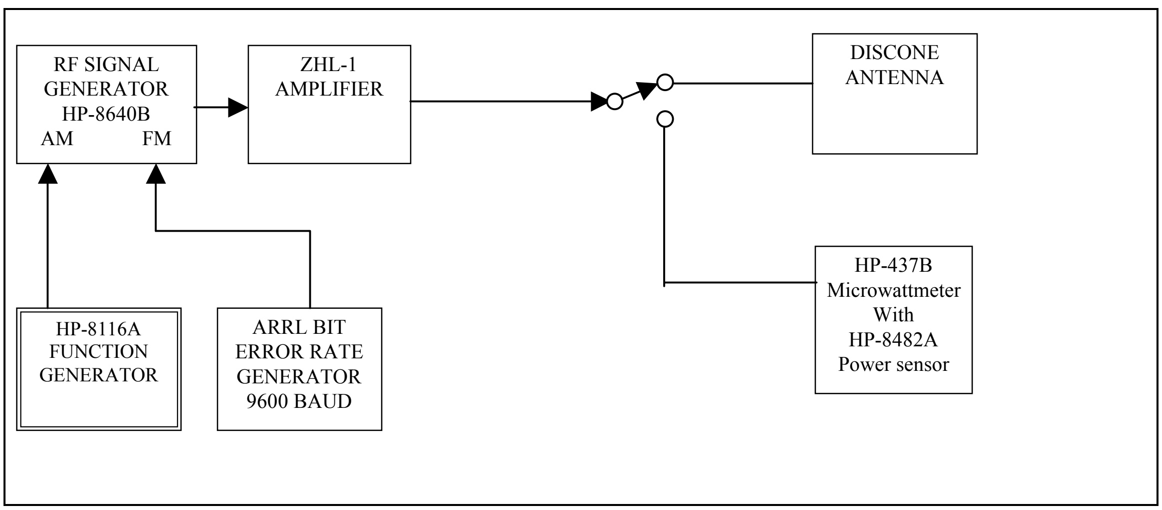

Figure 2. This fixture was used to generate a simulated RFID test signal of 3.63 milliwatts (-24.4 dBW) to the discone antenna.

An HP-8640B signal generator was used to generate the test signal. The generator was amplitude modulated with a positive going 7- ms pulse with a pulse repetition rate of 100 ms, supplied by an HP-8116A function/pulse generator. The amplitude of the pulse was adjusted so that the peak upward modulation of the signal was at the level of an unmodulated carrier and the downward modulation was 0%. The pulsed signal was simultaneously frequency modulated with a random 9600-bit/s stream, supplied by a bit-error-rate test generator constructed by ARRL. The signal generator deviation was adjusted to give a –6 dB occupied bandwidth of approximately 100 kHz, as measured on an HP-8563E spectrum analyzer. The output from the signal generator was amplified by a MiniCircuits ZHL-1 instrumentation amplifier to obtain enough signal level to overcome test fixture losses, including the loss on the feed line cable to the test transmit antenna.

Test Signal Levels:

The signal generator and other test equipment were placed in the ARRL Lab's shielded screen room. Approximately 60 meters of RG-8 coaxial cable connects the screen room to a discone antenna located on the roof. An HP-437B microwattmeter with an HP-8482A power sensor was used to measure the carrier power level on the rooftop at the end of this feed line. The carrier level to the antenna was set to 3.63 mW (-24.4 dBW) at the input to the discone antenna. The parameters of this test signal were designed to match the RFID systems described by Savi Technologies in their filings with the FCC.

Test Conditions:

As seen in Figure 2, an omnidirectional discone antenna was used as the source of the RFID signal. This antenna was mounted at a height of approximately 15 meters, without obstructions. It was assumed that this antenna has approximately 0 dBi of gain toward the horizon on 434 MHz.

Testing of the Impact of the Simulated RFID Signal on Amateur 70-cm CW and SSB Communications:

A satellite and terrestrial communications UHF station is located at W1AW, the ARRL Headquarters operator's club and bulletin station. This station includes a modern, commercially manufactured and widely used Amateur satellite transceiver (Kenwood TS-790), and a circularly polarized Cushcraft model 416TB Yagi array with 14.6 dBic of gain. This antenna is located on a tower at a height of approximately 20 meters, 90 meters horizontally distant from the discone. There is unobstructed line of sight between the two antennas. The Yagi receiving antenna is fed with 60 meters of one-half-inch rigid coaxial transmission line that has a calculated 3.9 dB of loss. No preamplifier was in use at the receiving antenna for these tests, thus yielding conservative results.

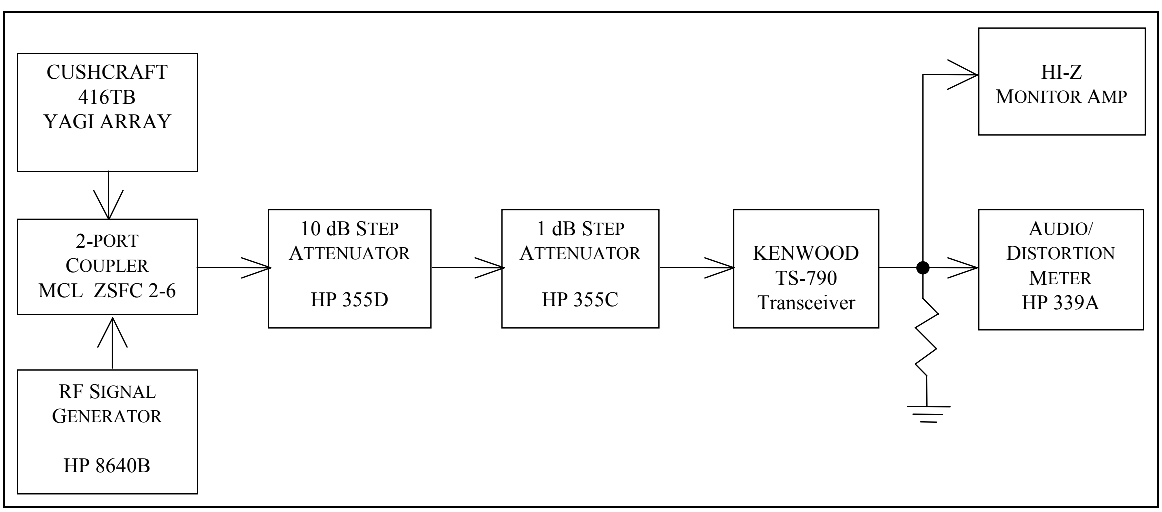

Figure 3. This fixture was used to measure the level of radiated received noise from the simulated RFID signal.

Tests:

The receiver sensitivity in a 500 Hz bandwidth was measured in the upper sideband mode, as –167 dBW for a 3 dB [S+N]/N. A receiver bandwidth of 500 Hz was selected as the narrowest available receiver bandwidth, to allow easy comparison to the test data ARRL has taken over decades of testing Amateur Radio equipment. Local noise was low.

The simulated RFID signal was then connected to the discone antenna feed line 90 meters away. The receiver was tuned to 433.92 MHz. The receiver S meter indicated S9+12 dB when the modulated simulated RFID signal was present, pulsing every 100 ms, and a steady S9+15 dB when an unmodulated carrier was transmitted. The HP-8640B shown in Figure 3 was then used to determine what level of receiver input gave an S9+12 dB signal strength meter indication. (The test method is included as Appendix A of this document.) This level was determined to be –106 dBW.

RSL Calculation for These Tests:

The measured results were in agreement with the levels that ARRL calculated using the same methods that it used in its previous submissions to the Commission in this proceeding.

Transmit power: -24.4 dBW
Adjustment for bandwidth (0.5 kHz / 100 kHz): -23 dB
Transmit antenna gain: 0 dBi
Adjustment for path loss (90 meters on 434 MHz): -64.3 dB
Equivalent linear receiving antenna gain: +11.6 dBi
Receiving antenna transmission line loss: -3.9 dB
Calculated Receive Signal Level: -104 dBW

Testing of the Impact of Simulated RFID Signals on Amateur Television Operation:

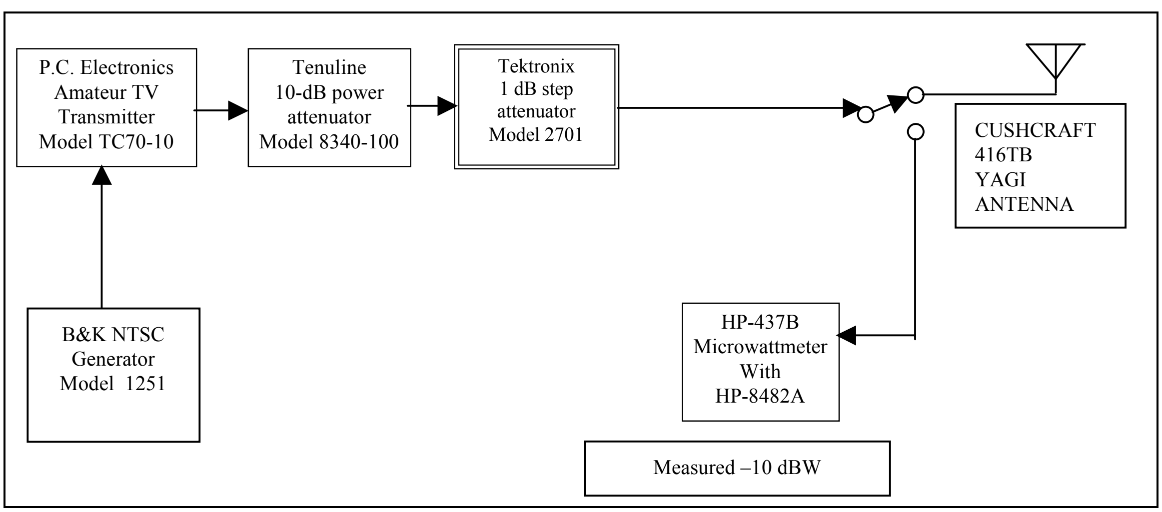

Figure 4. This fixture was used to generate an NTSC video color television signal on 434 MHz, operated under Part 97, for the television portion of this testing.

As a convenience, the transmitting antenna for the test fixture of Figure 4 was located on the rooftop of the ARRL HQ administrative building, approximately 20 meters high, at a distance of approximately 110 meters from the receiving antenna. The transmitting antenna gain is approximately 14.6 dBic.

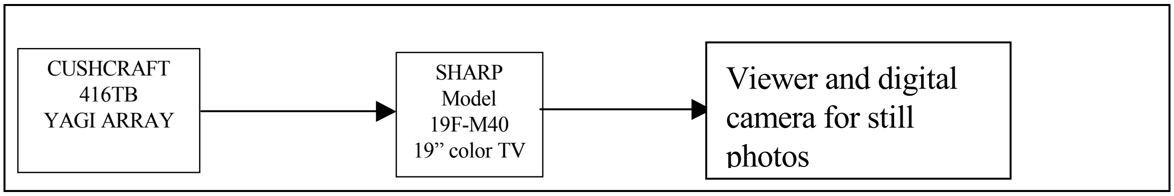

Figure 5. The impact on amateur television reception was made by a subjective viewer.

The satellite Yagi antenna and 60-meter feed line at ARRL Headquarters Amateur station W1AW was used for the ATV receiving tests. The signal received at W1AW was visibly snowy.

Figure 6, following, shows the received Amateur-television signal when no simulated RFID signal was present:

Figure 6. This ATV signal does not suffer interference when no simulated RFID signal is present.

Figure 1, at page 1, shows the effect of the simulated RFID signal on Amateur-television communication. The simulated signal was operated at an EIRP of approximately 3.6 milliwatts, located 90 meters from the television receive antenna. This level of interference would make Amateur-television communications impossible.

Conclusion:

SAVI's claim that Amateur Radio will not be impacted by the proposed rules changes is based on their determination that an RFID signal from their present systems does not break the squelch of an amateur FM receiver. Using a handheld FM receiver for over-the-air tests and using only squelch break as an indicator that none of the varied types of amateur communication will experience interference from the proposed RFID signals are flawed test premises. The SAVI test conditions do not address the wide varieties of amateur operating parameters and modes. ARRL has conducted the foregoing tests using a modest station in narrowband analog and amateur television modes to demonstrate that SAVI's conclusions are incorrect. ARRL's tests using modest amateur installations confirm that the proposed RFID levels at the 425-435 MHz frequencies will result in harmful interference to nearby amateur operations.

Appendix A: Receiver Sensitivity Measurement Method

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5.1 CW MINIMUM DISCERNIBLE SIGNAL (MDS) TEST

5.1.1 The purpose of the CW Minimum Discernible Signal (MDS) Test is to determine the level of signal input to the receiver that will produce an audio output that is 3 dB above the noise floor. The test is conducted with the receiver in the CW mode using the 500 Hz, or closest available, IF filters (or audio filters where IF filters are not available. For Devices Under Test (DUTs) that have appropriate IF filters, all audio filtering is disabled.) Set the AGC to the OFF position if possible. The test is performed at frequencies of 1.020 MHz, 3.520 MHz, 14.020 MHz, 50.020 MHz, 144.020 MHz and 432.020 MHz. For the expanded set of tests, this test is performed on all available amateur bands, 20 kHz above the lower band edge.

5.1.2 Test hook-up (See Fig. 5-1)

5.1.2.1 With all power switches in the OFF position, the transmitter function disabled to the fullest extent possible and the Generator RF switch OFF, connect the following:

Connection	Connectors	Cable Type
Sig Gen OUTPUT to 10-dB Step Attn INPUT	BNC to BNC	50 Ohm Coax
10-dB Step Attn OUTPUT to DUT RF INPUT	BNC to As Required	50 Ohm Coax
DUT AUDIO OUTPUT to Dist/Audio Meter INPUT	As Required to BNC	50 Ohm Coax
8-Ohm Load/HI-Z Amp Across Dist/Audio Meter Input	As Required	As Required
Power Source to DUT Power Input	As Required	As Required

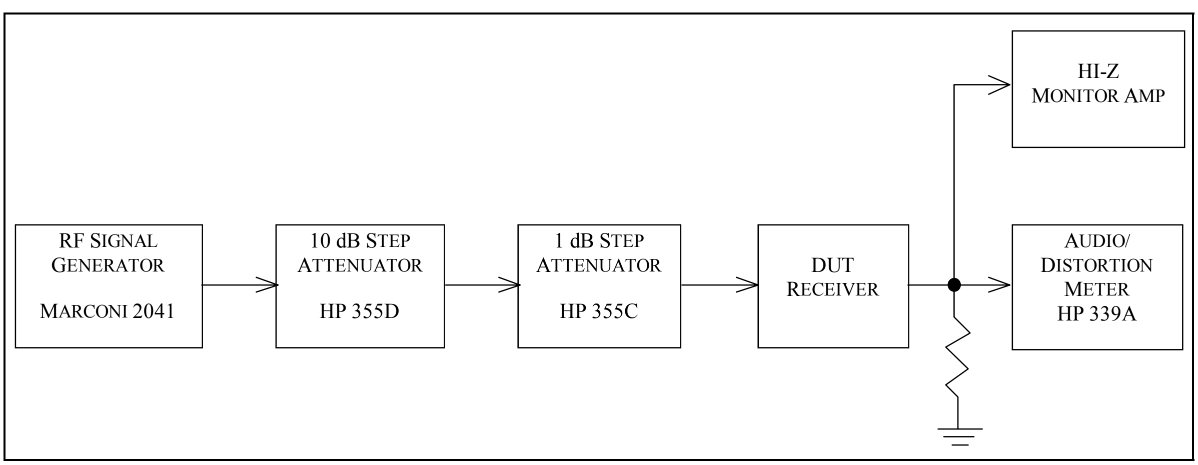

Figure 5-1 -- CW MDS Test Hook-up

5.1.3 Test Procedure

5.1.3.1 Turn the DUT and all test equipment power switches to ON. If the DUT does not cover 1.020 MHz, proceed directly to the second test frequency of 3.520 MHz. Set the following controls:

Instrument	Control	Position
DUT	Mode	CW
	Band Selector	As Required for 1.020 MHz
	Frequency	1.020 MHz
	XMIT/RCV	RCV
	DRIVE or RF LEVEL	Minimum
	IF Filters	500 Hz or Closest Available
	AGC	OFF
	Preamplifier	OFF
10 dB Step Attn	Attenuator	10 dB
RF Generator	CARRIER FREQ	1.020 MHz
	RF LEVEL	-110 dBm
	CARR ON-OFF	ON
	AM	Off
	FM	Off
	NOISE MODE (UTIL)	LOW NOISE
Audio/Distortion Meter	FUNCTION	REL LEVEL
	RELATIVE ADJUST	Center Rotation
	FILTERS	All Off (Out)
	INPUT RANGE	30 V
	INPUT/GND SELECT	DIS (Center)
	METER RESPONSE	NORM

5.1.3.2 Receiver hiss should be heard. Adjust the volume of the DUT and HI-Z monitor amp to the desired level. Allow all equipment at least 10 minutes warm-up time before proceeding to step 5.1.3.3.

5.1.3.3 Verify the RF Generator Output frequency has remained at 1.020 MHz. Reset if necessary.

5.1.3.4 Tune the receiver for 1.020 MHz. Adjust the INPUT RANGE and RELATIVE ADJUST controls as required to maintain approximately a midscale meter indication while carefully tuning the receiver for peak signal response. (Rotate the Generator OUTPUT LEVEL control as required until the signal is just heard in the receiver.)

5.1.3.5 Set the RF Generator RF switch to OFF. Decrease the Audio Meter INPUT RANGE until the meter indication is near midscale and the two lights above this control are out. Adjust the audio meter RELATIVE ADJUST control until the audio meter reads -6 dB on the upper scale. (Adjust the INPUT RANGE control one step in either direction if necessary.)

5.1.3.6 Set the RF Generator RF switch to ON. Rotate the generator OUTPUT LEVEL control to produce an audio meter reading of -3 dB. Ensure that the DUT is tuned for peak response.

5.1.3.7 Check to ensure that the Generator frequency is still at 1.020 MHz. Set the RF Generator RF to OFF. The audio meter should return to -6 dB. Turn the RF back on and the meter should again indicate -3 dB.

5.1.3.8 Determine the noise floor (MDS) of the receiver by computing the sum of the RF generator output in dBm and the 10 dB step attenuator. (NOTE: Be sure to include any additional attenuation you may have included in the line between the generator and the DUT.) Record on the Data Sheet.

Example: a) The RF generator is set for -128.6 dBm output.
b) The step attenuators are set for -10 dB.
c) The receiver MDS, therefore, is:

-128.6 - 10 = -138.6 dBm

5.1.3.9 Repeat steps 5.1.3.4 to 5.1.3.8 with DUT preamplifier set to ON.

5.1.3.10 Reset the generator output level to -110 dBm. Repeat paragraphs 5.1.3.3. to 5.1.3.9. for a test frequency of 3.520 MHz.

5.1.3.11 Repeat step 5.1.3.10 for a test frequency of 14.020 MHz.

5.1.3.12 Repeat step 5.1.3.10 for test frequencies of 50.020 MHz, 144.020 MHz and 432.020 MHz, as applicable to the DUT.

5.1.3.13 For an expanded set of tests, repeat step 5.1.3.10 for all remaining amateur bands.